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Maine Agricultural Experiment Station

ORONO

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SOIL TEST EXPERIMENT IN 1918

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BULLETIN 278

SOIL TEST EXPERIMENT AT AROOSTOOK FARM

SECOND REPORT

CHAS. D. WOODS

SUMMARY

This soil test experiment is conducted on Caribou loam on Aroostook Farm. While the results are probably of more or less general application to this type of soil they have no bearing on the fertilizer needs of other types of soil.

In this test available ammonia (nitrogen), available phosphoric acid, (phosphorus), and water soluble potash (potassium) were used singly, in combination by twos and by threes, in amounts varying from none to 240 pounds per acre.

This is a long term experiment designed to extend over many years.

The crops used are potatoes, oats and clover in a 3 year rotation.

Each plot and series of plots are in triplicate.

Two crops have been grown on each series of plots.

The yields of clover have been too uneven to make conclusions possible.

The oat stand in 1917 was very uneven. That of 1918 was fairly uniform on each plot.

The potatoes on each plot were quite uniform in both 1917 and 1918.

While only tentative conclusions can be drawn ammonia seems to be the limiting factor on this soil for oats, while neither phosphoric acid nor potash have much effect upon the yield of grain. Ammonia is also the limiting factor in potato yields, small amounts of potash increase the yield and phosphoric acid has no effect.

For Caribou loam on Aroostook Farm this soil test indicates that:

A fertilizer for oats should carry ammonia and that phosphoric acid and potash cannot be profitably applied.

A fertilizer for potatoes should carry ammonia and some potash while phosphoric acid will give no money return for its use.

These inferences will be tested with oats on large areas of Caribou loam on Aroostook Farm in 1919; those regarding potash have been tested and found to be true in the series of "no-potash experiments" that have been carried on at Aroostook Farm for the 4 past seasons; the inferences regarding phosphoric acid will be tested on Aroostook Farm, on 2 other farms in Presque Isle and 2 in Caribou in 1919. In all of these Caribou loam will be the type of soil used.

INTRODUCTION

Aroostook County, and particularly the part along the Aroostook River, has 2 characteristic soils that are used for cropping. These grade more or less from one into the other but nevertheless they are 2 well marked types. The best and most abundant potato soil, which occurs where the hard wood growth flourished, has been named by the United States Department of Agriculture's Bureau of Soils as Caribou loam. This by imperceptable gradations shades off into a dark brown or gray soil where the land was originally covered with black growth (conifers). To this soil the name Washburn loam was given. The principal soil type is the well drained "Caribou loam." This is the great potato soil of Aroostook County. Interspersing this is the poorly drained inferior "Washburn loam." Originally these soils were similar in origin, but through the centuries of plant occupation they have become biologically different.

One of the fundamental things in field agriculture is a knowledge of the soil that is being worked with. Much has been learned of Caribou loam from the experience of the men who have been cultivating it for a generation. Chemistry, soil physics, soil bacteriology and a study of the fungous organisms also contribute to the knowledge of this soil. But important as these sciences are, they chiefly serve to explain results obtained. There is one way—and only one way—to adequately

test a soil and learn its fertilizer needs. And that is by growing the plants to be studied in the soil.

After careful consideration of the difficulties and the expense involved the Station Council decided that all things considered there was no one thing that could be undertaken on Aroostook Farm better calculated to add to the knowledge of the permanent agriculture of the County than a long term experiment with fertilizers. The crops and the soil type were easily decided upon. Potatoes, oats and clover are now and are likely to be for many years to come the 3 standing staple crops of the county. And Caribou loam is the best and most common type of soil of the county.

The Plan of the Experiment.

The investment of time and money was to be so large that 2 years of time looking over literature, consulting with the best soil experimenters by letter and by visits to their operations were used before the final plans were adopted. As these plans are necessarily a compromise and cannot include all that one could wish and as it is hoped that this investigation may extend over many years of time the considerations that led to the adoption of the plan are here given in considerable detail.

The soil can be studied by growing plants in pots and under conditions where the growing conditions—moisture, shade, and the like—are under control or by growing the plants in the field. While there are many advantages in the greenhouse method, if only one of these methods can be employed, the advantages of growing the plants in the field offset its disadvantages.

In soil test experiments as heretofore conducted in this country and abroad the general plan has been to decide somewhat arbitrarily the amount of plant food to be used per acre and then apply the ammonia, phosphoric acid and potash, each by itself, in combinations of 2, and finally all 3 combined in these fixed amounts upon the different plots. The great weakness in this plan is that one assumes at the start that the amounts of the ingredients decided upon are the amounts best adapted to the crop. A more logical method would be to apply each ingredient to different plots in varying amounts from none

up to a point far beyond the amounts that would be likely to prove beneficial. After careful consideration this plan was adopted

THE TRIANGULAR DIAGRAM.

The triangular diagram as suggested by Schreinmacher, which has been of great service to physical chemistry where both theoretical and practical consideration of percentage composition of 3 component parts are concerned, has been adapted by Schreiner* to investigations in plant nutrition where it is desired to consider the 3 component parts, ammonia, phosphoric acid and potash, of a fertilizer mixture. It is possible to represent graphically any possible combination of mixtures of these 3 component parts by the use of an equilateral triangular diagram, as shown in figure 7.

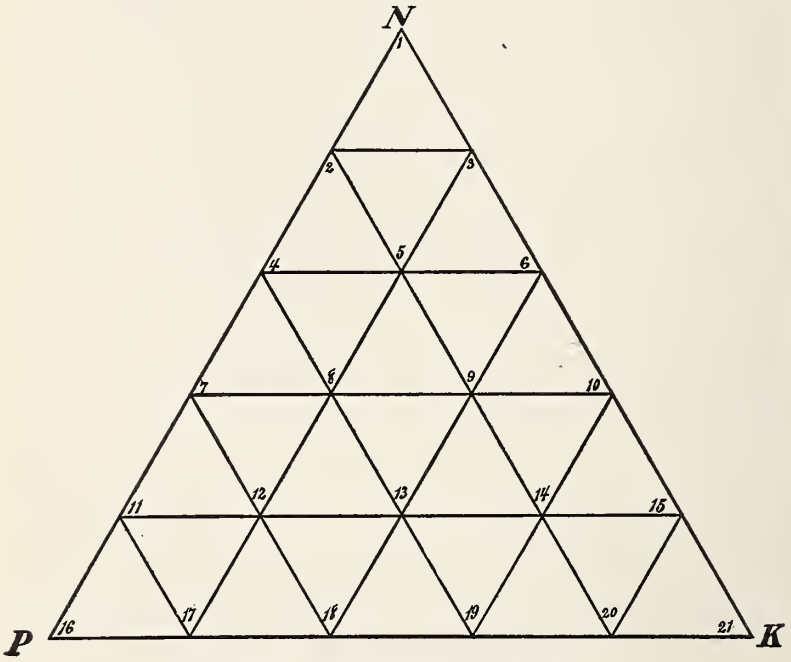


Fig. 7. The Triangular Diagram.

*Oswald Schreiner, Bureau of Soils, U. S. Department of Agriculture Bulletin 70, Botanical Gazette, Vol. 1, No. 1, and elsewhere.

The extreme points of the angles represent 100 per cent respectively of the ingredients ammonia (nitrogen) phosphoric acid (phosphorus) and potash (potassium). Obviously each side of the triangle can be divided into as many equal parts as may be desired. Schreiner in his work in the greenhouse with cultural solutions has been able to carry enough different combinations so as to divide the sides into tenths. That, however, makes 66 different combinations which is a far larger number than we could carry in this field test. Each side, therefore, is divided into fifths in the plan of the experiment here begun. And as explained beyond for the purpose of making the comparisons easier for the practical man familiar with usual fertilizer formulas, the 5-8-7 formula, which makes a total of 20 per cent of ammonia, available phosphoric acid and potash was used as a starting point. Hence, in the diagram here shown the extreme points of the triangle represent 20 per cent instead of 100 per cent as used by Schreiner. Although the fertilizer mixtures are in reality based upon the percentages expressed in terms of ammonia, phosphoric acid and potash the symbols N, P, and K for the elements nitrogen, phosphorus and potassium, which are the characteristic elements of these 3 constituents, are used in lettering. Wherever N is used in diagrams or text it refers to ammonia in available form, P refers to available phosphoric acid and K to water soluble potash.

The relation of the plots to each other is clearly seen by following the lines on the triangle. The maximum phosphoric acid (P) is at the left lower angle, the maximum potash (K) at the right lower angle and the maximum ammonia (N) is at the top of the triangle. From these points the different ingredients diminish. On all of the horizontal lines the phosphoric acid diminishes from left to right and the potash from right to left. On all of the lines inclined to the right the phosphoric acid decreases from bottom to top and the nitrogen decreases from top to bottom. On all of the lines inclined to the left the potash diminishes from the bottom to the top and the ammonia diminishes from the top to the bottom.

This plan calls for 21 plots. Obviously an indefinite number of plots could be introduced. To graduate on a scale of tenths would give finer distinctions but would treble the plots

over a division into fifths as shown in the illustration and as adopted in this experiment. In the scheme here adopted combinations of the 3 fertilizers in the amounts indicated at the intersection of the lines were used. The actual percentage composition of the fertilizers are given in Figure 9 and others beyond. Obviously the plot at each apex and the 2 adjoining carries the maximum amount of ammonia, phosphoric acid and potash respectively, while the 6 central plots carry mixtures of all 3 constituents.

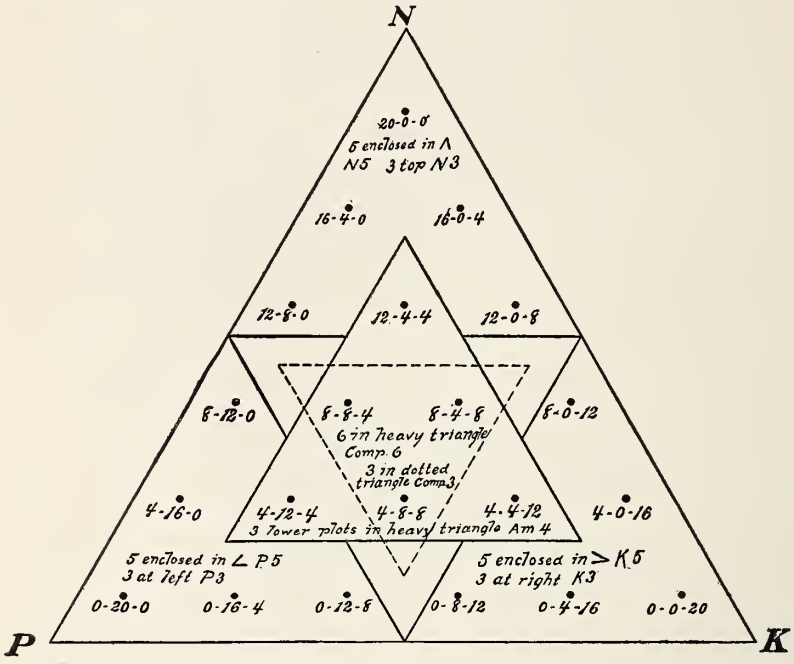


Fig. 8. The Relation of the plots in Groups.

Figure 8 shows diagramatically the relation of these plots in groups. The 5 plots enclosed in the Λ at the top of the figure are those in which ammonia predominates. The 3 plots nearest the top have the highest amounts of ammonia. In like manner the 5 plots enclosed in the < at the left at the bottom of the figure are those in which available phosphoric acid is the leading constituent with the 3 highest nearest the angle. Included in the > at the right corner of the figure are those highest in potash. The 6 plots in the heavy triangle in the

center of the figure contain all 3 of the ingredients and the 3 plots in the dotted triangle have them somewhat more nearly to ordinary percentages than do the others. While the 3 lowest plots in the heavy triangle have the ammonia in the amount that is fairly common in many high grade fertilizers. As noted in the figure for convenience of reference in the text, these groups are called N5, N3, P5, P3, K5, K3, Comp 6, Comp 3 and Am4. This plan and diagramatic arrangement makes comparative studies of the different combinations easier and more clearly shown than by any other method that has come to the attention of the writer.

THE FERTILIZING MATERIALS.

In the field experiments at Aroostook Farm with potatoes a 5-8-7 fertilizer or one that carrier 5 per cent of ammonia, 8 per cent of available phosphoric acid and 7 per cent of potash has been used at the rate of 1200 pounds per acre. The same formula at the rate of 300 pounds per acre is used when seeding to oats and at the rate of 150 pounds per acre as a top dressing on mowing fields. Obviously a 5-8-7 fertilizer carries 20 per cent of plant food. This amount of 240 pounds is absurdly high and it was, therefore, taken as a maximum in the scale so that on the diagram where ammonia is shown as 20 per cent it represents 240 pounds of ammonia. This amount of ammonia would be furnished by 4800 pounds of a 5-8-7 fertilizer.

The ammonia is one-third in the form of ammonium nitrate and two-thirds in the form of sulphate of ammonia. The phosphoric acid is in the form of acid phosphate. The potash is all water soluble and is being applied during the war in the form that can be obtained. In 1917 and in 1918 it was in the form of sulphate.

The weights of ammonia, phosphoric acid and potash applied to each plot when the crop is potatoes is shown in the table that follows.

For the 1-40 acre plots these amounts are divided by 40. These amounts are further reduced for application to oats by dividing by 120 and for application to grass by dividing by 240.

Application of Fertilizers Per Acre for Potatoes.

Treatment No.	Ammonia	Phosphoric Acid	Potash
1	0	240	0
2	0	192	48
3	48	192	0
4	0	144	96
5	48	144	48
6	96	144	0
7	0	96	144
8	48	96	96
9	96	96	48
10	144	96	0
11	0	48	192
12	48	48	144
13	96	48	96
14	144	48	48
15	192	48	0
16	0	0	240
17	48	0	192
18	96	0	144
19	144	0	96
20	192	0	48
21	240	0	0

It was also desired to compare the usual potato formulas of 5-8-7 and 3-8-10 goods, insoluble phosphate rock in the form of finely ground floats with acid phosphate, and nitrogen in the form of dried blood and in tankage with the mineral nitrogen used in the soil test. These 5 additional plots with 6 check plots increase the number of plots to 32.

The ingredients for the several fertilizer mixtures are weighed out and thoroughly mixed by hand. To insure even distribution each lot and plot are subdivided into fourths for the application of the fertilizer on the oats and clover Series and into sixths (as there are 6 rows in each plot) in the potato Series.

FIELD ARRANGEMENT OF PLOTS.

It was thought that to overcome lack of uniformity in soil each plot should be in triplicate. This makes a total of 96 plots. As potatoes are the important cash crop of Aroostook County it seemed important that potatoes should be grown annually. As it was prohibitive to increase the number of plots much above 100 because of the cost of caring for a larger number, it was decided to grow the plots in a 3 year rotation of potatoes, oats and clover. This plan not only gives a potato crop

SERIES A.

11 0-20-0	12	13	14 8-4-8	15 CHECK	16 12-0-8	17 0-4-16	18 4-12-4	19 0-8-12
21 ①4-8-8	22 CHECK	23	24 0-0-20	25 4-4-12	26 8-8-4	27 CHECK	28 ②4-8-8	29 5-8-7
31 12-4-4	32 16-0-4	33 4-8-8	34 CHECK	35 4-16-0	36 4-8-10	37 4-0-16	38 12-8-0	39 0-16-4
41 CHECK	42 8-12-0	43 16-4-0	44 ③4-8-8	45 8-0-12	46 CHECK	47 0-12-8	48 20-0-0	49 CHECK

SERIES B.

51 20-0-0	52 0-12-8	53 CHECK	54 8-0-12	55 5-8-7	56 16-4-0	57 8-12-0	58 CHECK
61 12-8-0	62 4-0-16	63 ①4-8-8	64 4-16-0	65 CHECK	66 4-8-8	67 16-0-4	68 12-4-4
71 4-8-10	72 CHECK	73 8-8-4	74 4-4-12	75 0-0-20	76 0-16-4	77 CHECK	78 ②4-8-8
81 4-12-4	82 0-4-16	83 12-0-8	84 CHECK	85 8-4-8	86 ③4-8-8	87 0-8-12	88 0-20-0

SERIES C.

91 CHECK	92 0-16-4	93 4-4-12	94 12-4-4	95 12-0-8	96 CHECK	97 5-8-7	98 0-4-16
101 8-0-12	102 4-8-8	103 CHECK	104 16-0-4	105 ①4-8-8	106 0-8-12	107 20-0-0	108 CHECK
111 0-0-20	112 16-4-0	113 4-16-0	114 4-8-10	115 CHECK	116 0-20-0		
121 ②4-8-8	122 CHECK	123 12-8-0	124 8-12-0	125 8-8-4			
131 8-4-8	132 0-12-8						
141 4-0-16	142 4-12-4						
151 ③4-8-8							

1 FLOATS.
2 DRIED BLOOD.
3 H. G. TANKAGE.

Fig. 9. Arrangement of plots in Field.

each year but it makes the experiment better in that the effects of unfavorable weather conditions of any single year are minimized. The field selected for the location of the plots contains about 5 acres. It is isolated from the other cultivated fields on the farm. It has a gentle slope toward the west.

The plots are in 3 series: A, consisting of 33 plots, one extra check plot being added to this series, B, 32 plots and C, 32 plots. The several plots in each series are separated by pathways 33 inches wide running lengthwise and 36 inches wide running crosswise, while the different series are separated by roadways 6 feet in width, running lengthwise. The arrangement of the plots in the field is shown in Figure 9 on page 41.

For convenience of reference the plots are numbered by row and by plot. Thus plot 11 is the first plot in the first row, while plot 36 is the sixth plot in the third row.

OUTLINE OF THE EXPERIMENT.

The field was in potatoes in 1914 and fertilizer was used at the rate of 1500 pounds per acre of a 5-8-7 fertilizer. In 1915, it was seeded to timothy and oats. In 1915 the land where this soil test now is was used for a trial of a commercial bacterial culture for root tubercles on legumes. At seeding, the land where Series A and C now are received 5-8-7 fertilizer at the rate of 500 pounds per acre. To Series B muriate of potash at the rate of 150 pounds per acre and acid phosphate at the rate of 300 pounds per acre were applied. In 1916 no fertilizer was applied.

The field was plowed shortly after cutting the grass in 1916. Early in the spring of 1917 the 97 plots required to carry on this experiment were surveyed, ecah plot being 1 rod wide by 4 rods long, or one-fortieth of an acre in area. The bounds are marked by permanent posts.

In 1917 Series A was planted to potatoes, Series B was seeded to oats and clover, and Series C was in clover. In 1918 Series C was in potatoes, Series A seeded with oats and clover, and Series B was in clover.

The full fertilizer application (see page 39) is used on the Series where potatoes are the crop, one-fourth the full

application is used on the Series in oats and one-eighth on the Series that are in clover.

THE 1918 YIELDS.

The yield of oats and potatoes obtained in 1917 are given in Bulletin 269. The tabulated yields for 1918 follow.

Soil Test Experiment. Series C Planted to Potatoes in 1918.

The table shows the number of the plots, the yields per plot and the calculated yields per acre. Each plot is one rod by four. They are arranged in rows 91-99, 101-109, etc. Fertilizer was applied at the rate of 1200 pounds per acre.

Plot No.	Fertilizer[4]	Yield per Plot		Yield per Acre Hundredweight		
		Merchantable	Culls	Merchantable	Culls	Total
		lbs.	lbs.			
91	Check	254.5	23.5	101.8	9.4	111.2
92	0-16-4	250.0	33.0	100.0	13.2	113.2
93	4-4-12	354.5	31.0	141.8	12.4	154.2
94	12-4-4	320.0	33.0	128.0	13.2	141.2
95	12-0-8	336.5	19.5	134.6	7.8	142.4
96	Check	175.0	39.5	70.0	15.8	85.8
97	5-8-7	282.5	45.0	113.0	18.0	131.0
98	0-4-16	159.5	32.0	63.8	12.8	76.6
101	8-0-12	396.5	20.5	158.6	8.2	166.8
102	4-8-8	367.5	23.5	147.0	9.4	156.4
103	Check	196.0	29.0	78.4	11.6	90.0
104	16-0-4	291.0	29.5	116.4	11.8	128.2
105	4-8[1]-8	326.5	26.0	130.6	10.4	141.0
106	0-8-12	196.0	41.0	78.4	16.4	94.8
107	20-0-0	202.0	33.5	80.8	13.4	94.2
108	Check	154.0	28.5	61.6	11.4	73.0
111	0-0-20	260.0	24.0	104.0	9.6	113.6
112	16-4-0	323.5	26.0	129.4	10.4	139.8
113	4-16-0	308.0	37.0	123.2	14.8	138.0
114	4-8-10	312.5	29.0	125.0	11.6	136.6
115	Check	238.5	23.0	95.4	9.2	104.6
116	0-20-0	170.5	41.0	68.2	16.4	84.6
121	4[2]-8-8	332.5	27.5	133.0	11.0	144.0
122	Check	251.0	25.5	100.4	10.2	110.6
123	12-8-0	392.0	29.0	156.8	11.6	168.4
124	8-12-0	338.5	38.0	135.4	15.2	150.6
125	8-8-4	346.0	35.0	138.4	14.0	152.4
131	8-4-8	315.0	25.0	126.0	10.0	136.0
132	0-12-8	280.0	21.5	112.0	8.6	120.6
141	4-0-16	285.5	24.5	114.2	9.8	124.0
142	4-12-4	284.0	29.5	113.6	11.8	125.4
151	4[3]-8-8	286.5	28.0	114.6	11.2	125.8

[1]Phosphoric acid in form of floats. [2]Ammonia in form of dried blood. [3]Ammonia in form of tankage. [4]The percentages of fertilizer are indicated in the order of ammonia, phosphoric acid and potash. Thus 0-20-0 means ammonia 0 per cent, available phosphoric acid 20 per cent and potash 0 per cent. Except as indicated otherwise in the footnote one-third of the ammonia is in the form of nitrate of soda and two-thirds as sulphate of ammonia; the phosphoric acid as acid phosphate and the potash in water soluble form.

Soil Test Experiment. Series A Planted to Oats in 1918.

The table shows the number of the plots, the yields per plot and the calculated yields of oats per acre. Each plot is one rod by four. They are arranged in rows 11-19, 21-29, etc. Fertilizer was applied at the rate of 300 pounds per acre.

Plot No.	Fertilizer[4]	Yield lbs. per Plot		Yield per Acre
		Grain	Straw	Grain
11	0-20-0	23.0	16.0	28.8
12	None	20.5	15.5	25.6
13	None	20.5	23.5	25.6
14	8-4-8	19.5	29.5	24.4
15	Check	16.0	23.0	20.0
16	12-0-8	20.0	19.0	25.0
17	0-4-16	17.0	19.0	21.3
18	4-12-4	10.0	19.0	12.5
19	0-8-12	9.0	10.0	10.0
21	4-8[1]-8	22.0	42.0	27.5
22	Check	20.0	24.0	25.0
23	None	23.5	25.5	29.4
24	0-0-20	15.5	20.5	19.4
25	4-4-12	14.5	16.5	15.0
26	8-8-4	13.5	22.5	16.9
27	Check	16.5	19.5	20.6
28	4[2]-8-8	14.5	21.5	15.0
29	5-8-7	9.0	15.0	11.3
31	12-4-4	26.5	49.5	33.1
32	16-0-4	24.0	37.0	30.0
33	4-8-8	20.0	39.0	25.0
34	Check	18.0	21.0	22.5
35	4-16-0	18.5	20.5	23.1
36	4-8-10	11.5	22.5	14.4
37	4-0-16	17.0	32.0	21.3
38	12-8-0	17.0	32.0	21.3
39	0-16-4	9.0	15.0	11.3
41	Check	22.0	27.0	27.5
42	8-12-0	19.0	35.0	23.8
43	16-4-0	18.0	21.0	22.5
44	4[3]-8-8	19.0	32.0	23.8
45	8-0-12	19.0	35.0	23.8
46	Check	14.0	20.0	17.5
47	0-12-8	11.0	10.0	13.8
48	20-0-0	23.0	51.0	28.8
49	Check	15.0	16.0	18.8

[1]Phosphoric acid in form of floats. [2]Ammonia in form of dried blood. [3]Ammonia in form of tankage. [4]The percentages of fertilizer are indicated in the order of ammonia, phosphoric acid and potash. Thus 0-20-0 means ammonia 0 per cent, available phosphoric acid 20 per cent and potash 0 per cent. Except as indicated otherwise in the footnote one-third of the ammonia is in the form of nitrate of soda and two-thirds as sulphate of ammonia; the phosphoric acid as acid phosphate and the potash in water soluble form.

Soil Test Experiment. Series B Planted to Clover in 1918.

The table shows the number of the plots, the yields per plot and the calculated yields per acre. Each plot is one rod by four. They are arranged in rows, 51-58, 61-69, etc. Fertilizer was applied at the rate of 150 pounds per acre.

Plot No.	Fertilizer[4]	Yield per Plot—Lbs.	Tons per Acre
51	20-0-0	83	1.66
52	0-12-8	88	1.76
53	Check	48	.96
54	8-0-12	37	.74
55	5-8-7	51	1.02
56	16-4-0	50	1.00
57	8-12-0	69	1.38
58	Check	26	.52
61	12-8-0	79	1.58
62	4-0-16	64	1.28
63	4-8[1]-8	47	.94
64	4-16-0	57	1.14
65	Check	61	1.22
66	4-8-8	79	1.58
67	16-0-4	57	1.14
68	12-4-4	43	.86
71	4-8-10	68	1.36
72	Check	47	.94
73	8-8-4	63	1.26
74	4-4-12	64	1.28
75	0-0-20	32	.64
76	0-16-4	76	1.52
77	Check	44	.88
78	4[2]-8-8	29	.58
81	4-12-4	80	1.60
82	0-4-16	49	.98
83	12-0-8	68	1.36
84	Check	31	.62
85	8-4-8	51	1.02
86	4[3]-8-8	58	1.16
87	0-8-12	53	1.06
88	0-20-0	55	1.10

[1]Phosphoric acid in form of floats. [2]Ammonia in form of dried blood. [3]Ammonia in form of tankage. [4]The percentages of fertilizer are indicated in the order of ammonia, phosphoric acid and potash. Thus 0-20-0 means ammonia 0 per cent, available phosphoric acid 20 per cent and potash 0 per cent. Except as indicated otherwise in the footnote one-third of the ammonia is in the form of nitrate of soda and two-thirds as sulphate of ammonia; the phosphoric acid as acid phosphate and the potash in water soluble form.

NOTES ON THE EXPERIMENT IN 1918.

Series A on which Maine 340 oats were planted and Series C on which potatoes were planted in 1918 were plowed in the fall of 1917. Series B clover plots remained from the previous season's seeding. The ingredients of the several fertilizer mixtures were carefully weighed and mixed by hand. Fertilizer for oats and clover plots was applied broadcast while that for the potato plots was applied in the row. The clover plots were harvested August 6, and the hay weighed in the field, after curing. The seed sown was composed of equal quantities of Alsike and Red Clover. Not over 10 per cent of the stand was red clover. Fertilizer was applied May 9.

The fertilizer was applied to the oat plots on May 9 and planting was completed the same day. During the season some variation of color in the plants was noticed on the several plots. This, however, was not nearly so marked as observed on the potato plots. These plots were harvested on August 30.

Fertilizer was applied to the potato plots on May 9 and planting was completed the same day. On June 19 the potato plants being about 6 inches in height, a heavy frost occurred freezing the vines to the ground. They did not fully recover from this set-back for the remainder of the season.

The variation in color ranged from a very light green on the check plots and on the low nitrogen plots through a normal medium green on the plots carrying more or less balanced fertilizer, up to a very dark, deep green shade on the no-potash plots. The dark green color of the no-potash plots was so distinct that these plots stood out in striking contrast to the remaining plots. The plots were thoroughly sprayed with bordeaux mixture during the season and no evidence of late blight was observed. The plots were harvested on September 23, 1918.

DISCUSSION OF RESULTS.

Although this is designed as a long term experiment and only after the accumulation of several years' results can very definite conclusions be reached, it is interesting and instructive to make certain comparisons from year to year as the experiment proceeds.

OATS. SERIES A 1918.

The plots arranged in their relations to fertilizer used are shown in the following triangular diagram. The yield of straw is omitted from the diagram but is given in the table on page 44.

Diagram of Oat Soil Test Experiment 1918. Series A.

*The top number above the * is the plot number. The numbers connected by the - show the fertilizer formula, applied at the rate of 300 pounds per acre. The letters N, P and K indicate the parts of the triangle where ammonia, available phosphoric acid and potash are respectively at their maximum amounts. The numbers below the * give the yield of oats per acre. The arrangement of the plots is shown by the diagram on page .*

N
Highest Ammonia

48
20-0-0
*
29

43
16-4-0
*
23

32
16-0-4
*
30

38
12-8-0
*
21

31
12-4-4
*
33

16
12-0-8
*
25

42
8-12-0
*
24

26
8-8-4
*
17

14
8-4-8
*
25

45
8-0-12
*
24

35
4-16-0
*
23

18
4-12-4
*
13

33
4-8-8
*
25

25
4-4-12
*
15

37
4-0-16
*
21

11
0-20-0
*
29

39
0-16-4
*
11

47
0-12-8
*
14

19
0-8-12
*
10

17
0-4-16
*
21

24
0-0-20
*
19

P
Highest Phosphoric Acid

K
Highest Potash

15 0-0-0 * 20	22 0-0-0 * 29	27 0-0-0 * 21	34 0-0-0 * 23	41 0-0-0 * 28	46 0-0-0 * 18
49 0-0-0 * 19	29 5-8-7 * 11	36 4-8-10 * 14	21 4-8[1]-8 * 28	28 4[2]-8-8 * 15	44 4[3]-8-8 * 24

[1]Phosphoric acid in form of floats. [2]Ammonia in form of dried blood. [3]Ammonia in form of tankage.

In 1917 (See page 25 Bulletin 269) the yields were uneven largely because of the uneven stand due to seasonal causes. The yields were published but are meaningless as regards the effect of fertilizers.

In 1918 the stands were fairly uniform and while not much can be learned from a single year's results they are worthy of study.

Grouped by the plots at the points of the triangle and by the center plots (See diagram page 38), the average yields are:

	Bushels grain
Three ammonia plots, N3 in diagram	27
Five ammonia plots, N5 in diagram	26
Three available phosphoric acid plots, P3 in diagram	21
Five available phosphoric acid plots, P5 in diagram	20
Three potash plots, K3 in diagram	20
Five potash plots, K5 in diagram	19
Three center plots, Comp3 in diagram	22
Five center plots, Comp5 in diagram	21
Three lower center plots, Am4 in diagram	18
Three left center plots, Phos acid side	21
Three right center plots, Potash side	24
Six check plots	23

Although as discussed below there seems to be an unevenness in the soil that was not expected when the test was begun, the above tabulation indicates clearly that ammonia (nitrogen) is the limiting factor in oat production as it was found to be in 1917 with potatoes on this Series.

This is more clearly brought out in arranging the results, as below, in the order of the ammonia (nitrogen) content.

Six no ammonia plots	17
Five 4 per cent ammonia plots	19
Four 8 per cent ammonia plots	22
Three 12 per cent ammonia plots	26
Two 16 per cent ammonia plots	27
One 20 per cent ammonia plot	29

The inference from the first tabulation given above that phosphoric acid and potash had little influence on the yield is shown in the following tabulations for these elements. The series in the triangle that carried no ammonia are omitted since

ammonia (nitrogen) was the limiting factor and their introduction would mask the effects of phosphoric acid and potash.

Five no phosphoric acid plots	26
Four 4 per cent phosphoric acid plots	24
Three 8 per cent phosphoric acid plots	21
Two 12 per cent phosphoric acid plots	19
One 16 per cent phosphoric acid plot	23
Five no potash plots	24
Four 4 per cent potash plots	23
Three 8 per cent potash plots	25
Two 12 per cent potash plots	20
One 16 per cent potash plot	21

CLOVER. SERIES B, 1918.

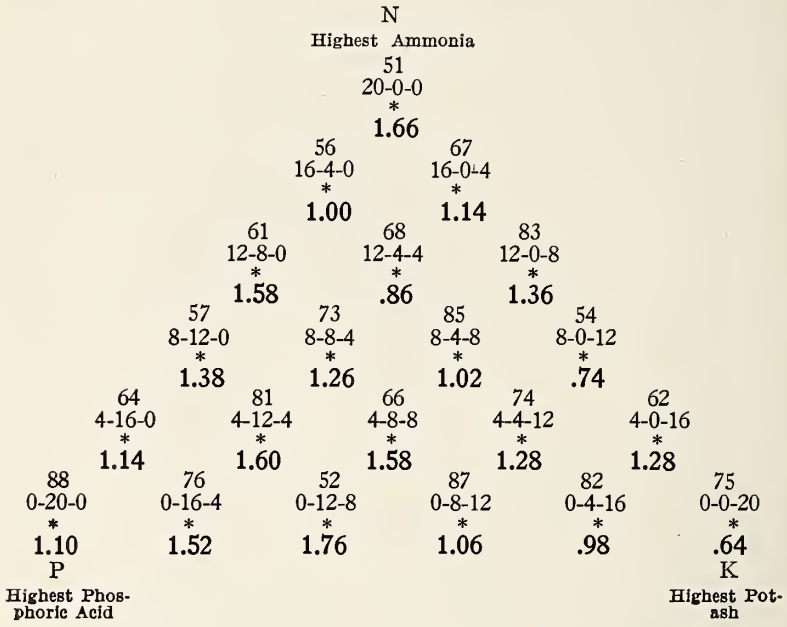
The clover plots (Series C) in 1918 were not harvested but were plowed under in the fall of 1917 in preparation for the 1918 plotato plots. Series B 1918 were seeded to clover with oats in the spring of 1917. A mixture of equal parts red clover and alsike clover were used. The crop of 1918 was composed of about 9 parts alsike to 1 part red clover.

As indicated by the varying yields obtained on the check plots, factors such as stand, residual plant food, possible lack of lime etc., on some plots evidently had far more to do with the yield of clover than the fertilizers had. During the whole of the growing season the plots were apparently very uneven in stand, thrift and general appearance. On the check plots as well as the plots that are fertilized fairly alike the yields have very little relation to the fertilizer used or the location of the plots in the field. The lowest yield on a chick plot was less than half that on the almost adjoining check plot. Clover is supposed to respond to mineral fertilizers rather than to ammonia, but the highest yield was from the plot carrying only ammonia in the added fertilizer and the lowest yield on any fertilizer plot was that to which potash was applied.

The plots arranged in their relation to the fertilizer applied are shown in the following triangular diagram.

Diagram of Clover Soil Test Experiment 1918. Series B.

*The top number above the * is the plot number. The numbers connected by - show the fertilizer formula, applied at the rate of 150 pounds per acre. The letters N, P and K indicate the parts of the triangle where ammonia, available phosphoric acid and potash are repectively at their maximum amounts. The numbers below the * give the yield in tons per acre of field cured clover. The arrangement of the plots in the field is shown by the diagram on page*



CHECK PLOTS

53	58	65	72	77	84
0-0-0	0-0-0	0-0-0	0-0-0	0-0-0	0-0-0
*	*	*	*	*	*
.96	.52	1.22	.94	.88	.62

SPECIAL FORMULAS

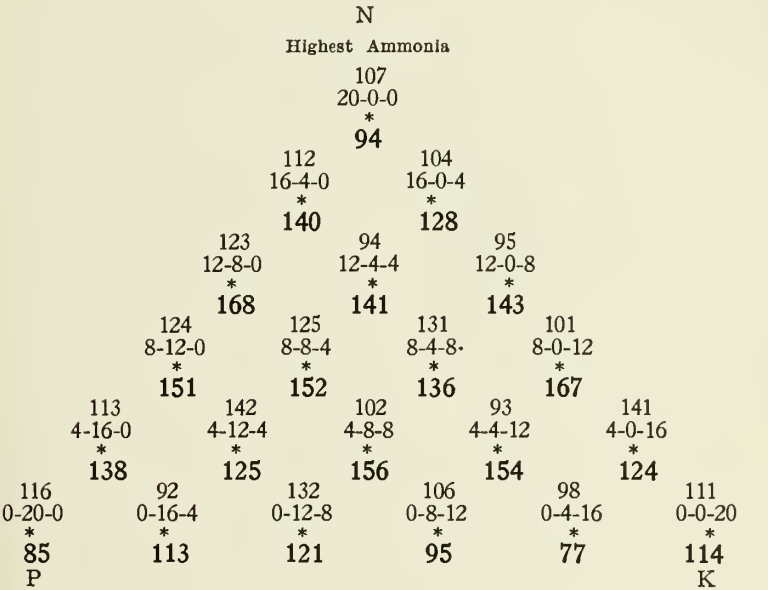
55	71	63	78	86
5-8-7	4-8-10	4-8[1]-8	4[2]-8-8	4[3]-8-8
*	*	*	*	*
1.02	1.36	.94	.58	1.16

[1]Phosphoric acid in form of floats. [2]Ammonia in form of dried blood. [3]Ammonia in form of tankage.

POTATOES 1917 AND 1918. SERIES A AND C.

Diagram of Potato Soil Test Experiment 1918. Series C.

*The top number above the * is the plot number. The numbers connected by the - show the fertilizer formula, applied at the rate of 1200 pounds per acre. The letters N, P and K indicate the parts of the triangle where ammonia, available phosphoric acid and potash are respectively at their maximum amounts. The numbers below the * give the yield in hundredweights per acre. The arrangement of the plots in the field is shown by the diagram on page*



91 0-0-0 * 111	96 0-0-0 * 86	103 0-0-0 * 90	108 0-0-0 * 73	115 0-0-0 * 105	122 0-0-0 * 110
	97 5-8-7 * 131	114 4-8-10 * 137	105 4-8[1]-8 * 141	121 4[2]-8-8 * 144	151 4[3]-8-8 * 126

[1]Phosphoric acid in form of floats. [2]Ammonia in form of dried blood. [3]Ammonia in form of tankage.

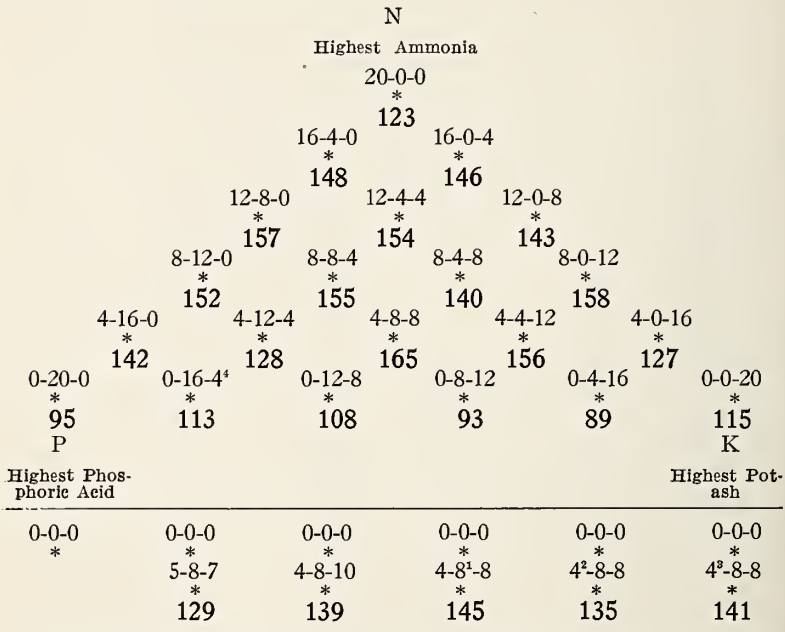
The results for 1917 were given in detail in Bulletin 269. In 1918 the stand was even and other than the killing frost when the plants were about 6 inches high and from which they did not fully recover, the experiment was successful.

The plots, Series C, 1918, arranged in their relations to fertilizer used are shown in the following triangular diagram.

The plots showing the average yields in 1917 and 1918, arranged in their relation to the fertilizers used are shown in the following triangular diagram.

Diagram of Potato Soil Test Experiment 1917 and 1918. Series A and C.

*The numbers above the * and connected by the - show the fertilizer formula used each year and applied at the rate of 1200 pounds per acre. The letters N, P and K indicate the parts of the triangle where ammonia, available phosphoric acid and potash are respectively at their maximum amounts. The numbers below the * give the average yields per acre in hundredweights.*



[1]Phosphoric acid in form of floats. [2]Ammonia in form of dried blood. [3]Ammonia in form of tankage. [4]Omitting this plot for 1917.

Grouped by the plots at the points of the triangle and by the center plots (See diagram page 36) the average yields are:

	Hundredweight per acre		
	1917	1918	1917-18
Three ammonia plots, N3 in diagram	157	121	139
Five ammonia plots, N5 in diagram	152	135	143
Three available phosphoric acid plots, P3 in diagram	103	112	108
Five available phosphoric acid plots, P5 in diagram	111	122	117
Three potash plots, K3 in diagram	115	105	110
Five potash plots, K5 in diagram	117	115	116
Three center plots, Comp3 in diagram	158	148	153
Six center plots, Comp6 in diagram	154	144	149
Three lower center plots, Am4	153	145	149
Seven check plots	109	96	103

There are uneven yields but the limiting effect of nitrogen is again shown in 1918. Its preponderance is shown by arranging the results in the order of the ammonia in the fertilizer mixtures.

	Hundredweight per acre		
	1917	1918	1917-18
No ammonia 5 plots*	101	101	101
Four per cent ammonia 5 plots	147	139	144
Eight per cent ammonia 4 plots	150	151	151
Twelve per cent ammonia 3 plots	152	150	151
Sixteen per cent ammonia 2 plots	160	139	147
Twenty per cent ammonia 1 plot	151	94	123

*Omitting plot 39 for 1917.

Average yield from plots carrying ammonia and potash and no phosphoric acid in the fertilizer mixtures.

	Hundredweight of potatoes		
	1917	1918	Average
Average yield 4 plots	150	149	150

Average yield from plots carrying ammonia and phosphoric acid and no potash in the fertilizer mixtures.

	Hundredweight of potatoes		
	1917	1918	Average
Average yield 4 plots	146	141	144

The above tabulations show that omitting phosphoric acid from the fertilizer had no effect upon the yield, while omitting

the potash reduced the yield 6 hundredweight. This is in accord with the results that have been obtained in the so-called no-potash experiments conducted the past 4 years on Caribou loam on Aroostook Farm. The application of as little as 30 pounds of potash per acre increased the yield about 20 per cent. The application of larger amounts gave no further increase.

These results for the 2 years seem to warrant the tentative conclusions that on Caribou loam on Aroostook Farm while nitrogen is the limiting fertilizing factor, a small amount of potash* is also needed to produce maximum yields.

THE RESULTS FROM THE PLOTS ARE UNEVEN.

The field selected for this soil test experiment was carefully considered before the soil test was begun. The first year the Station had the farm (1914) this field was in potatoes. Fifteen hundred pounds per acre of 5-8-7 fertilizer was used. The yield while not very large was apparently even over the whole piece. The next year it was seeded to oats and timothy. The yield of oats in 1915 and of timothy in 1916 seemed to be uniform over the piece. The field was plowed soon after haying in 1916 and the plots were laid out. It was hoped that a detailed soil survey would be made by the experts of the Federal Department of Agriculture. But such a study has not as yet been practicable. A preliminary survey that was made confirmed the opinion formed from the 3 crops that had been harvested by the Station as to its probable uniformity. Nothing was known of the treatment of the field prior to its purchase by the State. The former owner carried quite a number of head of dairy animals and applied the manure to the land. This was applied in the convenient, but not from the standpoint of uniform application desirable, way of drawing into piles in the field and later distributing it. Such a practice

*The fact is well known that during the past few years partial or almost entire crop failures have been experienced on certain other types of soil not only in Aroostook County but in other parts of Maine and the remainder of New England as well, where no-potash fertilizers have been used for potatoes. In Aroostook these crop failures due to lack of potash are almost wholly confined to the Washburn loam or closely related soils.

would make the supply of plant food uneven. But as this field was a long distance from the buildings and until the Station took possession separated from the rest of the farm by a run with a very bad road, it is not likely that great amounts of farm manure had been taken to this field.

In Series A, with potatoes in 1917, the plots in the ninth row (19, 29, 39, and 49) gave low yields. Plot 19 is without nitrogen in the fertilizer. And with ammonia as the limiting factor a small yield would be expected. Plot 29 had a special mixture of 5-8-7 formula. Its yield was about 20 hundredweight below what one would have expected. Plot 39 was also without ammonia in the fertilizer. During the whole season of 1917 the plants on plot 39 had a discouraged look and the yield was even lower than that on the check plot 49. And the yield on this check plot was about 20 hundredweight below the next lowest check plot and nearly 30 hundredweight below the average yield for the check plots.

With 2 crops, one of potatoes and one of oats, on the plots on Series A and with nitrogen the limiting factor in both crops on this land, it is possible to draw some inferences as to the uniformity of the soil on the different plots from these yields.

As the plots are numbered in rows from east to west by a row and plot number, thus plot 11, means row 1, plot 1, it makes it that from south to north all the plots in which the figure 1 is the second figure in the plot number are in one row or tier, and all the plots with 2 the second figure are in the next tier etc., (see diagram of field page 41). Hence the plots can be considered in a south to north relation as well as an east to west. Plots treated with ammonia, phosphoric acid and potash, and check plots and no ammonia plots occur in nearly every south and north tier. The yields from the fertilized plots and the check plots and those without ammonia in the mixture are tabulated by tiers of plots and again by groups of 3 tiers in the table that follows.

The field slopes gradually from the east to the west. The plots are numbered from east to west. Therefore the groups of plots in which the second figure is 1 is at the east side of the field and they progress toward the west until the last group with 9 as the second figure is reached. It will be noted that

in the complete fertilizer plots and in the check and no ammonia plots when grouped by threes (rows 1 to 3, 4 to 6, and 7 to 9) the yields are the largest at the east end and decrease pretty regularly toward the west.

Although the resulting yields indicate that the field is not as uniform as it was hoped the experiment will be continued for at least another growing season.

Table showing yields per rows of the plots that have complete fertilizer (ammonia, phosphoric acid and potash) and plots that carried no fertilizer or a fertilizer without ammonia. The yields of the potatoes in 1917 are given in hundredweights and of oats in 1918 in bushels per acre.

Tier	Complete fertilizer plots			Checks and no ammonia plots		
	Number plots	Crop Yields		Number plots	Crop Yields	
		Potatoes	Oats		Potatoes	Oats
1	2	158	31	1	105	29
2	1	164	30	1	133	29
3	2	164	24	0	0	0
1 to 3	5	161	28	2	119	29
4	2	149	24	2	117	21
5	2	153	20	1	111	20
6	3	147	19	1	108	18
4 to 6	7	149	21	4	113	20
7	1	129	21	3	99	17
8	2	128	14	0	0	0
9	1	126	11	2	86	15
7 to 9	4	128	15	5	94	17